THE WEATHER AND CIRCULATION OF DECEMBER 1959

An Abrupt Change From A Cold Fall Season

CHARLES M. WOFFINDEN

Extended Forecast Section, U.S. Weather Bureau, Washington, D. C.

1. INTRODUCTION

At the close of November 1959, a warm, maritime regime became established over most of North America and persisted throughout December with only minor variations. The pattern of mild temperatures which ensued contrasted sharply with the unseasonable cold of November and, indeed, came close to being the exact opposite. Thus the cool regime which characterized the fall season as a whole [1] terminated abruptly as winter approached.

The mean trough in the 700-mb. contours for the month of December (fig. 1) extended diagonally from Newfoundland across the contiguous United States into lower California. A number of storms, some of which reached blizzard proportions, developed over the Southwest and moved east-northeastward in association with the trough. The result was a wet and snowy month over much of the nation's mid-section.

2. THE MEAN MONTHLY CIRCULATION

One of the most noteworthy aspects of the mean monthly circulation pattern for December (fig. 1) was the marked strength of the zonal westerlies over the oceans as compared to the very weak flow over the continents. Over both the Atlantic and the Pacific, mean wind speeds in the jet stream at 700 mb. exceeded 20 m.p.s. in isotach centers (fig. 2). These speeds were as much as 6 m.p.s. above normal in the Pacific and 10 m.p.s. in the Atlantic. As these currents approached western coasts, however, both underwent marked difluence. For example, the separation between the 9,200-ft. and 10,200-ft. contours expanded from roughly 20° of latitude over oceanic areas to 40° over the continents. On the other hand, flow along or off eastern coasts was subjected to equally marked confluence, so that gradients became restored over the oceans. As far as the Western Hemisphere was concerned, the strength of the maritime westerlies more than balanced the subnormal continental flow, and the resultant mean zonal index for the month over the Western Hemisphere was 1.9 m.p.s. above normal.

CHANGE IN MEAN CIRCULATION FROM NOVEMBER

The largest changes in 700-mb. height departure from normal from November [2] to December 1959, occurred over the Western Hemisphere (fig. 3). The pattern of anomalous change—a large rise center over Canada, another over the central Pacific, and a region of falls in between—was adequate to completely alter the phase of the circulation. Thus, the deep troughs of large amplitude which dominated the central Pacific and North American regions during November gave way to ridges, and a second trough developed in the eastern Pacific southward from the Gulf of Alaska. Such a fundamental shift in circulation is not the usual case from November to December. In fact, an earlier study by Namias [3] indicated that flow patterns between these two months are more likely to be similar than different.

It was over North America, however, that the reversal of pattern was most dramatic in both circulation and weather. As a result of the extensive area over which heights increased (fig. 3) a broad, flat, westerly flow ensued which introduced mild prevailingly maritime air to almost all of Canada and the United States. Mean thickness values for December of the layer 1,000 to 700 mb. (not shown) were well above normal over almost the whole of North America, ranging as high as +330 ft. in central Canada. This change in circulation evolved as a blocking surge retrograded from its November seat over northern Scandinavia (hence the height falls in that area in fig. 3) to the Canadian region early in December. Thereafter the general pattern proved remarkably stable, and it was not until the closing days of the month, when the blocking finally retrograded to the Gulf of Alaska, that the pattern changed and cold continental air was successful in invading the contiguous United States.

Changes from November to December in the Atlantic, while less pronounced than over North America, were in the direction of increasing the westerly flow and deepening the European trough. Thus the geometry of the November pattern was roughly maintained, but with greatly intensified circulation. Under the steering influence of this flow, numerous severe storms crossed the Atlantic

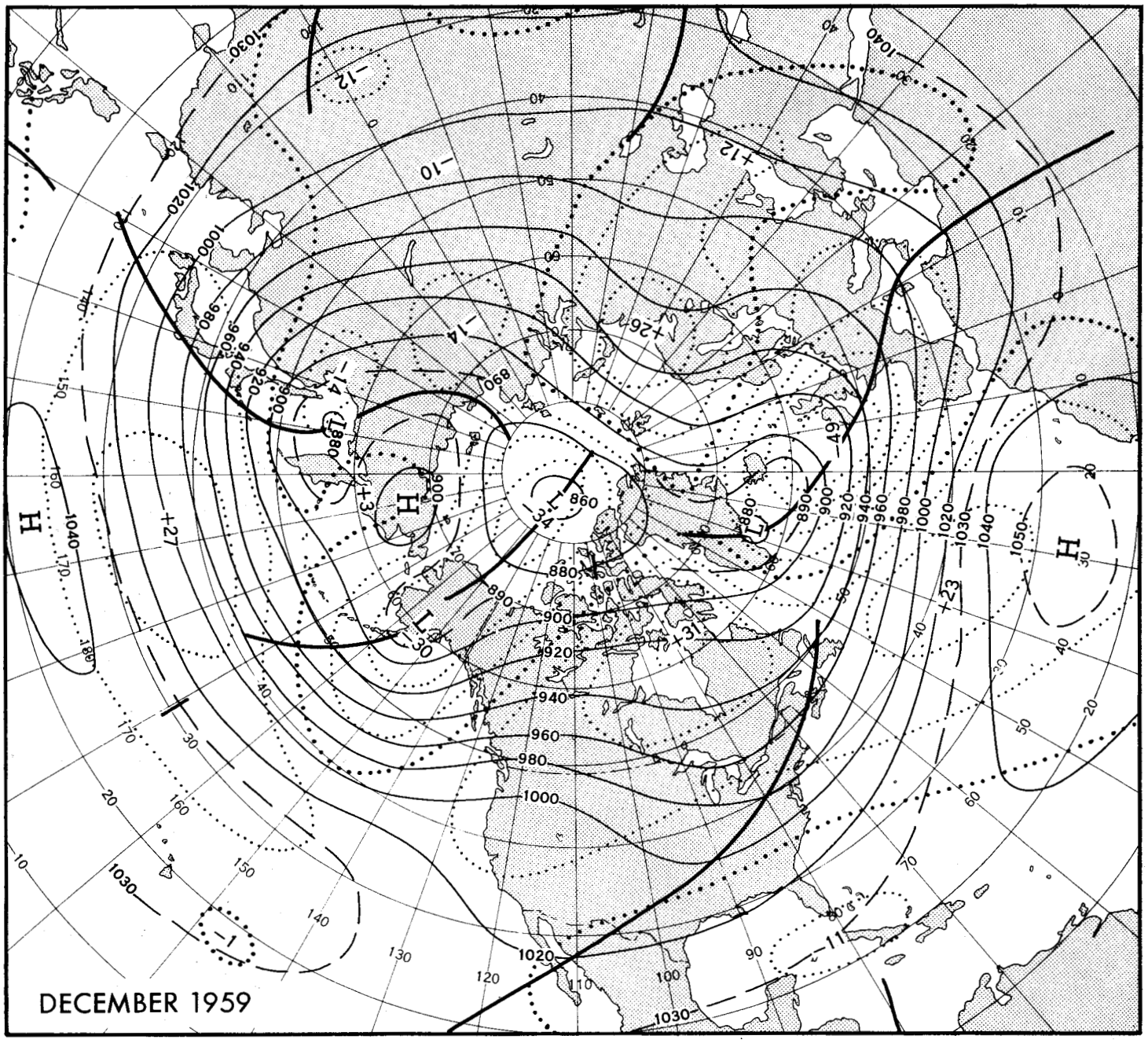

FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for December 1959. Troughs are indicated by heavy lines. Zonal flow was unusually strong over the oceans and weak over the continents. The circulation over the United States was mainly zonal but difluent in the West and confluent in the East, leading to a warm but wet month over much of the country.

and plunged southeastward across Europe and into the Mediterranean. In this manner the British Isles and all of western and southern Europe suffered a period of intense, persistent storminess.

TEMPERATURE

As mentioned previously, the configuration of the mean monthly 700-mb. chart (fig. 1) favored the advection of mild maritime air into the United States and Canada. As a consequence, except for the extreme Southeast and the Great Basin, above normal temperatures prevailed over the entire country, with departures as much as 12° F. in the northern Plains (fig. 4). This pattern stood in sharp contrast, not only to that of the previous month, but also to that of the fall season as a whole. Both these periods were predominantly cold, with the coldest air relative to normal centered in the northern Plains, precisely where December was the warmest.

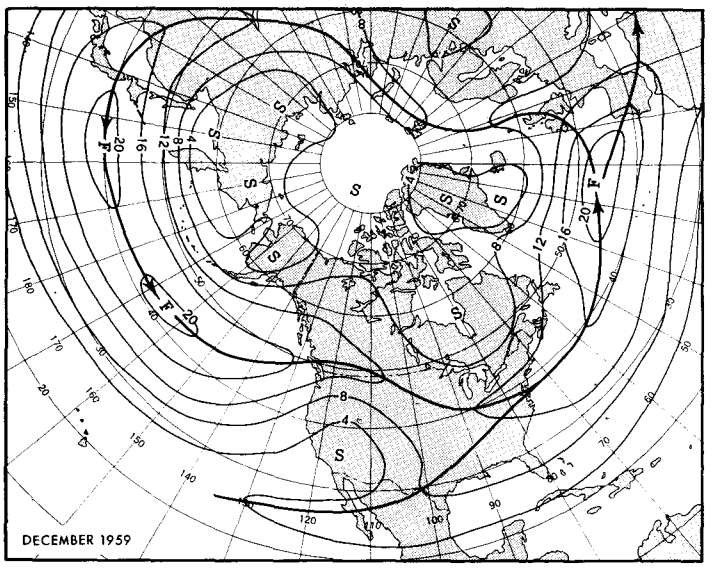

FIGURE 2.—Mean isotachs (in meters per second) of 700-mb. wind speed during December 1959. Solid arrows indicate axes of maximum wind speed. The zonal westerlies were much stronger and better organized over the oceans than over the continents, where there was a tendency to split into two branches.

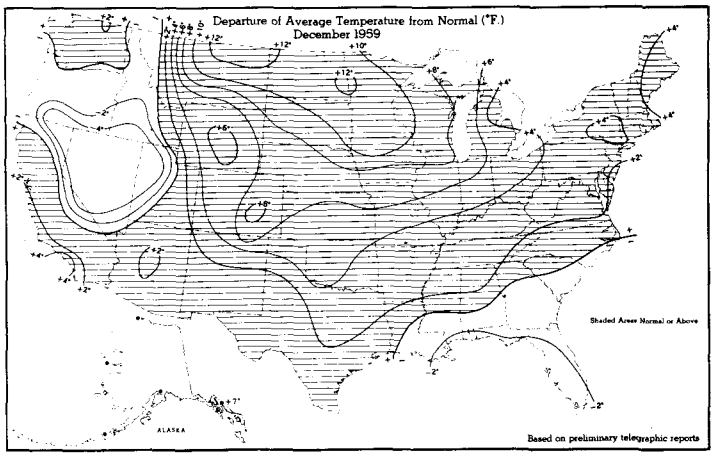

FIGURE 4.—Departure of average temperature (° F.) from normal for December 1959. Hatching indicates areas of normal or above normal temperatures. Unusually mild weather prevailed over most of the United States, with below normal temperatures confined to the Great Basin and the extreme Southeast. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVII. No. 1, Jan. 4, 1960.)

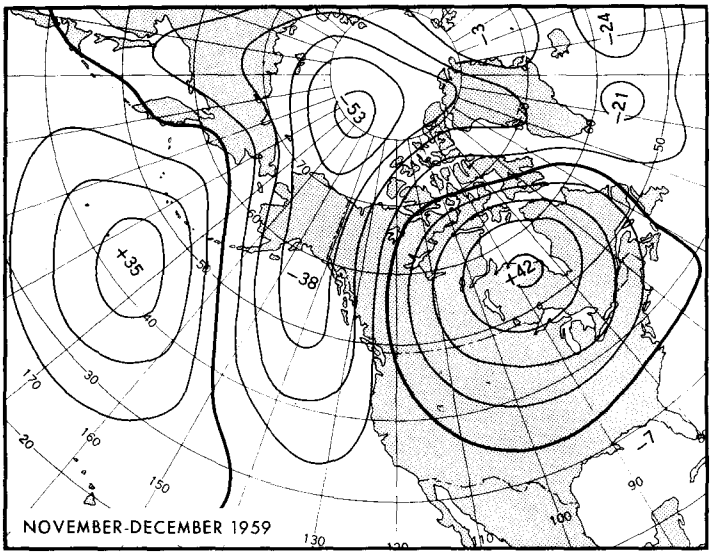

FIGURE 3.—Difference (in tens of feet) between the mean monthly 700-mb. height departures from normal of November and December 1959. Greatest changes took place over the Arctic Basin where heights dropped as much as 530 ft. At middle latitudes, the large rises over Canada and the central Pacific and the falls between completely reversed the circulation pattern of November in the Western Hemisphere.

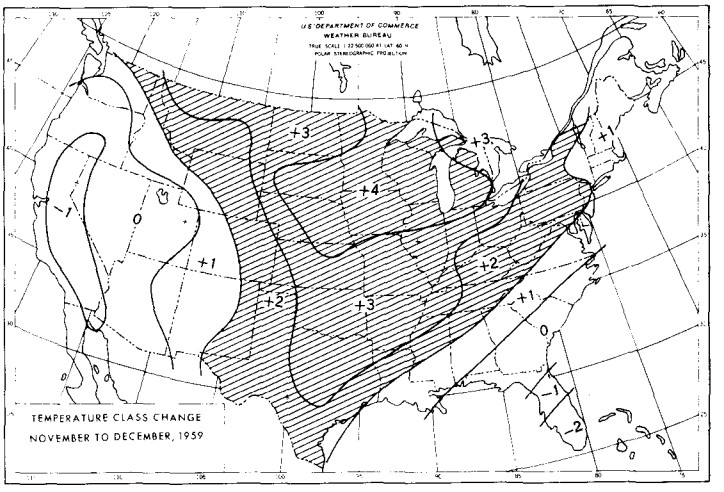

FIGURE 5.—The number of classes (out of 5) the surface temperature anomaly chan ed from November to December 1959. With the except on of Florida, much warmer temperatures dominated the country eastward from the Continental Divide. Temperature reversals of this magnitude and extent are uncommon between this pair of months.

Thus a long period of sustained cold in the northern Plains was abruptly terminated in December, and an equally remarkable period of persistent warmth was inaugurated. In fact, December averaged warmer than November in an absolute as well as an anomalous sense over a wide area embracing the Central States from Kansas northward. This constitutes a rare event indeed, and for many stations was a first occurrence. At Rapid City, N. Dak., for example, December's average was 6.3° F. warmer than November's. At a rather long list of stations including Duluth, Minn., Huron, S. Dak., Devils Lake and Bismarck, N. Dak., Burlington and Waterloo, Iowa, this was the first time in 60 years that December averaged warmer than November, with the difference amounting to a sizable 4° F. at the first three locations listed.

TABLE 1.—*Departure from normal of mean maximum and mean minimum temperature for December 1959 at selected western stations.* (°F.)

Station	Departure from normal	
	Maximum temp.	Minimum temp.
Winnemucca, Nev.	+4.4	−13.5
Salt Lake City, Utah	0.0	−6.5
Red Bluff, Calif.	+6.1	−3.1
Fresno, Calif.	+5.1	−4.0
Pocatello, Idaho	+3.2	−4.4

The mild weather was also remarkably persistent as the temperature at several stations remained above normal each day of the month. This was true at Fargo and Bismarck, N. Dak., St. Cloud, Minn., and Huron, S. Dak., to list a few. The variability on 5-day mean maps over Montana and the Dakotas consisted mainly of changes between the above and much above normal temperature categories.

Figure 5 depicts the change in mean temperature class [1] from November to December. The extensive area of hatching indicates the region over which the monthly temperature increased by two or more classes. Cooling was restricted to Florida, the western Great Basin, and the interior valleys of California. Temperature oscillations of this type, although they do occur, are rarely of this magnitude in December. In this instance, temperatures changed by two or more classes at 63 percent of the cities, a figure which has been exceeded only once since computation of this statistic was begun in 1942 [3]. Interestingly enough this single occurrence was in December 1958 when the corresponding figure was 68 percent [4]. On that occasion, however, the reversal was in the opposite sense, with December the colder rather than the warmer month.

Below normal temperature in the Great Basin occurred principally because of nocturnal cooling. Daytime maxima were actually above normal, and these apparently were more representative of the prevailing mild Pacific air masses because the mean temperature at the 700-mb. level averaged 3° to 4° above normal. Table 1 lists the departure from normal of average maximum and average minimum temperature for several stations in the Plateau area and the interior valley of California. The latter are included because the radiational cooling effect there was quite similar, though insufficient in that case to offset daytime warming.

At Winnemucca, Nev., the average spread between the maximum and minimum temperatures amounted to 36.3° F., exceeding the normal diurnal range by 17.9° F. This remarkable difference illustrates the marked effect which shallow radiation inversions can exert even on monthly averages. In this case the average temperature was reduced sufficiently to make this December the coldest in 27 years, even though the average maximum temperature remained above normal, and not a single pronounced outbreak of cold Canadian air can be traced into that region during the month. This effect, which is favored by the light winds and clear skies accompanying the Great Basin anticyclone, has been noted on 5- and 30-day mean maps on a number of previous occasions, and a particularly pronounced case has been described by Ross and Vederman [5] from the point of view of daily activity.

The California coastal region continued to experience unusual warmth. Los Angeles, San Francisco, and San Diego all reported departures from the 1921–50 surface temperature normal of +3° or more. Thus the warm regime which began a few years ago and characterized each previous month of 1959 continued unabated into December. At San Diego and Los Angeles the mean annual temperature for 1959 broke the record for all previous years, though 1958 was a close second. At San Francisco, on the other hand, 1958 was the warmest year, with 1959 next. In any event, the normals currently in use appear to have been highly unrepresentative during recent years, as discussed by several authors (e.g. [1,6]).

Florida was the only other portion of the country where temperatures averaged below normal. This occurred mainly during the first of the month as the cold polar air which had dominated most of the country during November lingered in the Southeast. Florida experienced its coldest weather of the season during this period when temperatures dropped 8° to 10° below normal levels, and freezing conditions extended well into the interior of the peninsula.

The Alaskan circulation was dominated by a deep trough extending southward from an intense polar vortex (fig. 1). The associated anomalous northerly flow introduced extremely cold air from off the Arctic ice cap into western Alaska. At Nome the monthly mean temperature of −7.1° F. was 14.8° below normal, the coldest December since records began in 1907. In advance of the trough, on the other hand, conditions were generally milder than normal, and anomalously strong, onshore winds brought very heavy snows to coastal regions. Yakutat, for example, was buried under 84.9 in. of snow, and Anchorage experienced 31.2 in., nearly three times as much as the average.

PRECIPITATION

Precipitation was heavy over a broad band extending from the Southwest across northern Texas northeastward to New England (fig. 6). Several major storms followed this course, accompanied by gale winds, heavy rain or snow, and in some cases sleet and freezing rain. The first system, though relatively weak, crossed the California coast on the 9th and gave a foretaste of things to

[1] Temperature anomalies are divided into the following classes: much above and much below normal (12½ percent occurrence each) and above, near normal, and below (25 percent occurrence each).

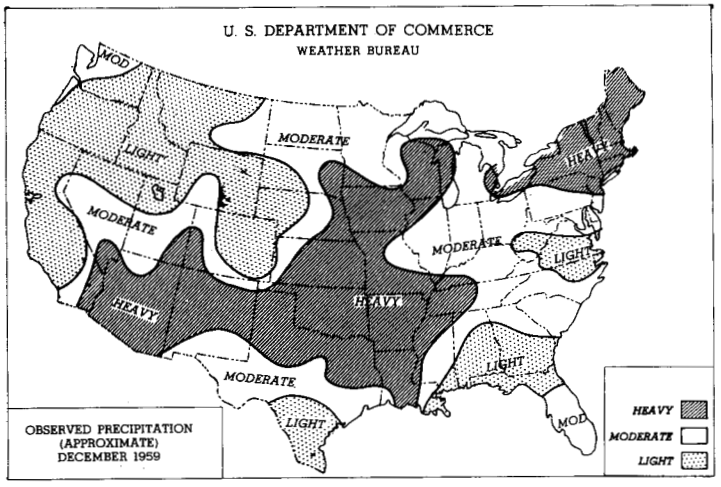

FIGURE 6.—Approximate observed precipitation for December 1959. (The classes heavy, moderate, and light normally each occur ⅓ of the time.) Unusually wet weather extended from Arizona eastward to the Texas-Oklahoma region, thence northeastward to the Lakes and the Northeast.

come by bringing snows of up to 10 in. in the mountain areas of central Arizona and New Mexico before moving on toward the east-northeast. Thereafter, three severe storms traversed roughly the same area, affecting the Southwest on the 13–14th, the 25–26th, and the 30–31st. As a result, precipitation was exceptionally heavy over Arizona, New Mexico, and portions of Oklahoma and Texas. Amarillo, Tex. established a new record with a monthly total of 4.52 in., and Phoenix, Ariz., a near record of 3.46 in. At Albuquerque, N. Mex., the accumulated snowfall of 14.7 in. established a new record for any month, exceeding by ½ in. the previous high value set in December 1958.

The rainfall released by these storms was particularly welcome over portions of the Great Basin and California where drought conditions had been developing for some time. However, at most locations, accumulations for the year continued substantially below normal, and additional moisture was badly needed. At some points, notably Reno and Winnemucca in Nevada, the drought actually intensified, and streams and reservoirs were either completely dry or at much below normal levels.

One of the most intense of these storms crossed the California coast on the 24th, produced a stormy Christmas in the southwestern United States, and subsequently headed toward the Great Lakes, bringing heavy snows and blizzard conditions over an extensive portion of the country from the mountain areas of Arizona across the Plains States to New England. The snowfall in Wisconsin in connection with this storm was the heaviest in 20 years, and in Rochester, N.Y., the ice damage was termed the worst in the city's history. In addition to heavy snows, sleet fell in the interior portions of the Northeast, and onshore, easterly gales generated heavy seas and caused widespread coastal flooding in Massachusetts on December 28 and 29. The region was

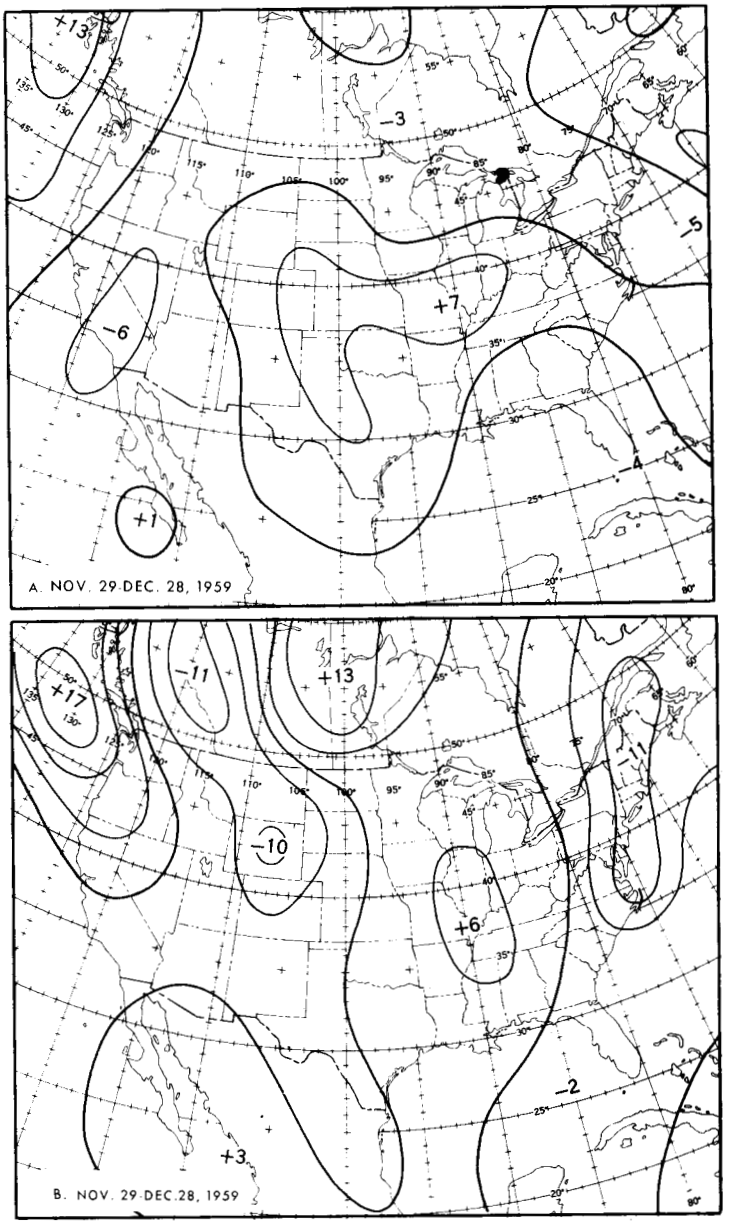

FIGURE 7.—(A) Estimate of the departure from normal of the 30-day mean vertical motion for December 1959 in units of mm. sec.$^{-1}$, with positive values indicating upward motion. This chart was calculated by applying the equivalent-barotropic model to the observed 500-mb. mean chart for December 1959 and to the normal 500-mb. contours for the month and taking the difference. (B) Estimate of the 30-day mean vertical motion for December 1959 in mm. sec.$^{-1}$ obtained by advecting the mean 850–500-mb thickness for the month with the observed mean 500-mb. flow.

declared a disaster area, and damage to coastal installations was estimated in the millions. The preceding disturbance also had been a heavy producer of snow in the southwestern Great Plains and of rain over most of the South. As a result of the two storms several streams in the lower Mississippi Valley approached or exceeded flood stage. Damages were relatively minor, for the most part, as the overflow was confined to low-lying agricultural areas.

Precipitation was subnormal in the Northwest under the mean upper-level ridge and was particularly deficient along the slopes of the Rockies from Colorado northward where warm, dry foehn winds prevailed most of the month. Typical of this regime was Cheyenne, Wyo., where only 0.03 in. fell to make this December the driest since 1905. Lee locations in Colorado were similarly dry, with Colorado Springs limited to 0.03 in. and Pueblo to a mere trace, thus ranking this month among the driest of all time. This is of particular interest, since stations not far to the south in northern New Mexico and Texas were setting new records for snowfall. Other regions of below normal precipitation occurred in the Southeast and in portions of the Virginias, a somewhat surprising circumstance since both areas lay near or in advance of the mean trough in an area of broad cyclonic curvature.

In a recent article of this series [7] the vertical motion associated with a mean monthly 700-mb. chart was computed using the Extended Forecast Section model described by Clapp [8]. This model is of the equivalent-barotropic type and the vertical motion arises from the assumption that the wind direction is invariant with height, necessitating certain divergence in the layers above and below the level assumed nondivergent. This divergence was shown [7] to be proportional to the relative vorticity advection at 500 mb. and the ratio between the wind speeds at 500 and 750 mb. To the extent that the equivalent-barotropic assumption holds, and it is probably reasonably satisfied on mean charts, the resulting vertical motion fields can be considered characteristic of the flow pattern. Since an estimate of orographic influence was not incorporated in this model, one should not be surprised if poor correspondence occurs over the intermountain areas of the West where such effects are likely to dominate. Such a computation was made from the mean 500-mb. chart for December 1959. Figure 7A represents the difference between values of vertical velocity computed from this month's 500-mb. contours and from the long-period normal. Comparison with the observed rainfall (fig. 6) reveals a fairly good similarity between the two patterns The wet area in the central Plains was associated with anomalous ascent, and the dry regions of the intermountain Northwest and the Southeast with subsidence (relative to normal). On the other hand, the very heavy precipitation over Arizona and the Northeast was poorly indicated, as was the unusual dryness in the leeward portions of Wyoming and Colorado. However, as has already been mentioned, the latter phenomenon can be attributed to foehn warming which this model does not simulate.

Figure 7B depicts the advection of the mean thickness field (850 to 500 mb.) observed during December 1959 by the mean 500-mb. flow for the month. If the mean thickness field is assumed stationary, the results can be interpreted in terms of vertical motion [7]. Also in this case, the resulting pattern (fig. 7B) bears a resemblance to the precipitation distribution, though again with marked discrepancies. The precipitation in the central portion of the country matched well with indicated upward motion (warm advection), but the very heavy rainfall in the Southwest and Northeast did not. In fact, the Northeast was subjected to marked cold advection in the mean. However, examination of the individual 5-day mean charts shows warm advection for relatively short periods prior to passage of storms, followed by relatively long intervals of cool advection, so that the latter dominated the monthly pattern. This emphasizes the difficulty encountered in attempting to specify a discontinuous parameter such as precipitation from smoothed charts in which the individual eddies are suppressed.

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